Tevatron Experimental Issues at High Luminosities

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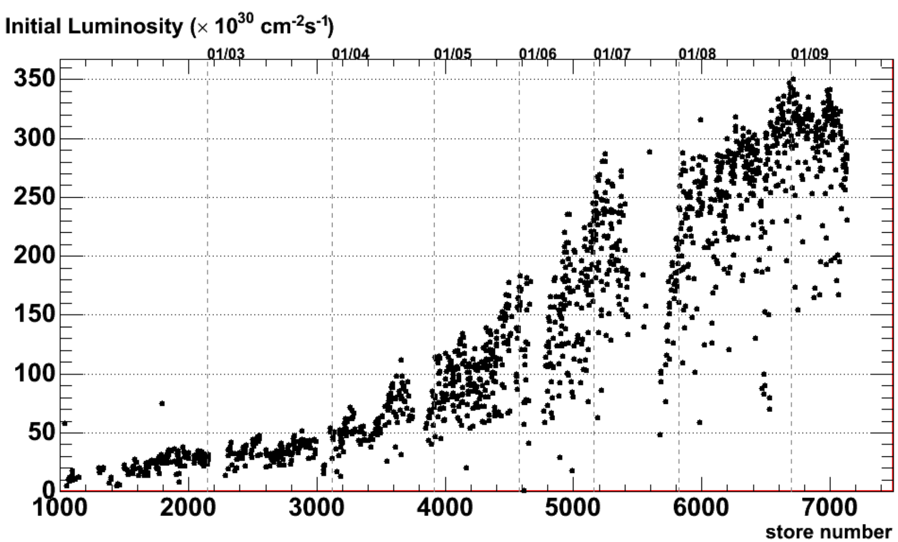
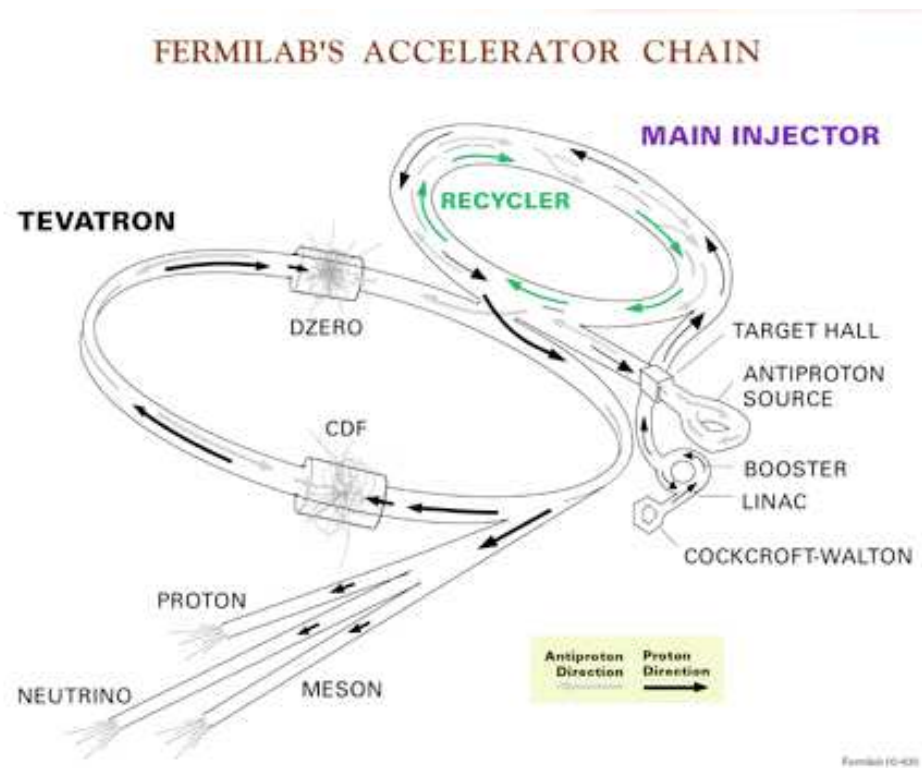
On behalf of the CDF and DØ Collaborations

Tevatron

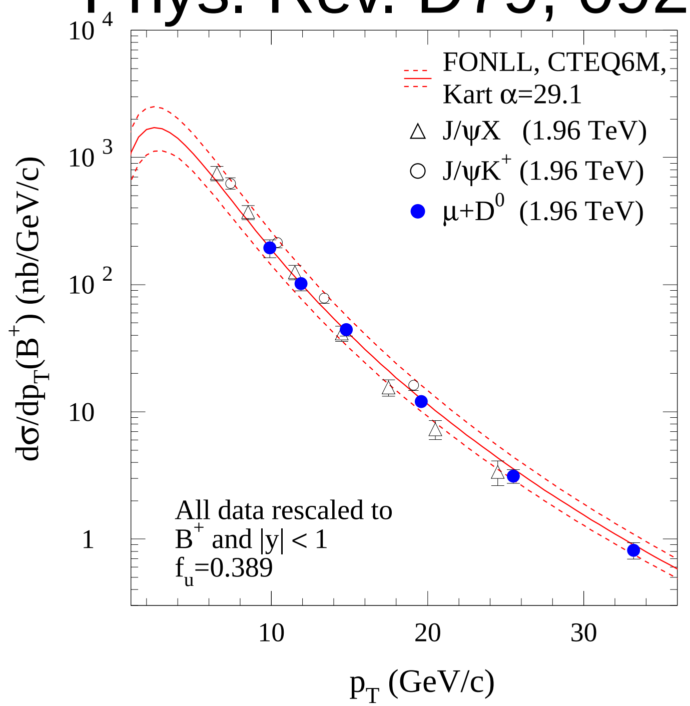
- $p\bar{p}$ collisions at $\sqrt{s} = 1.96\,\text{TeV}$
- Peak luminosity $\approx 3.3 \cdot 10^{32}\,\text{cm}^{-2}\text{s}^{-1}$
- Almost $7\,\text{fb}^{-1}$ delivered

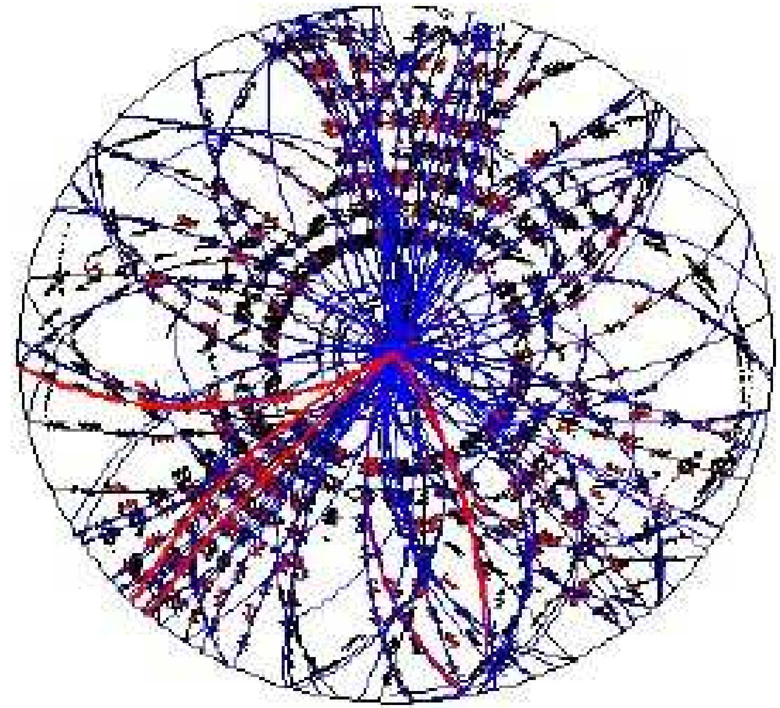




Heavy flavor production

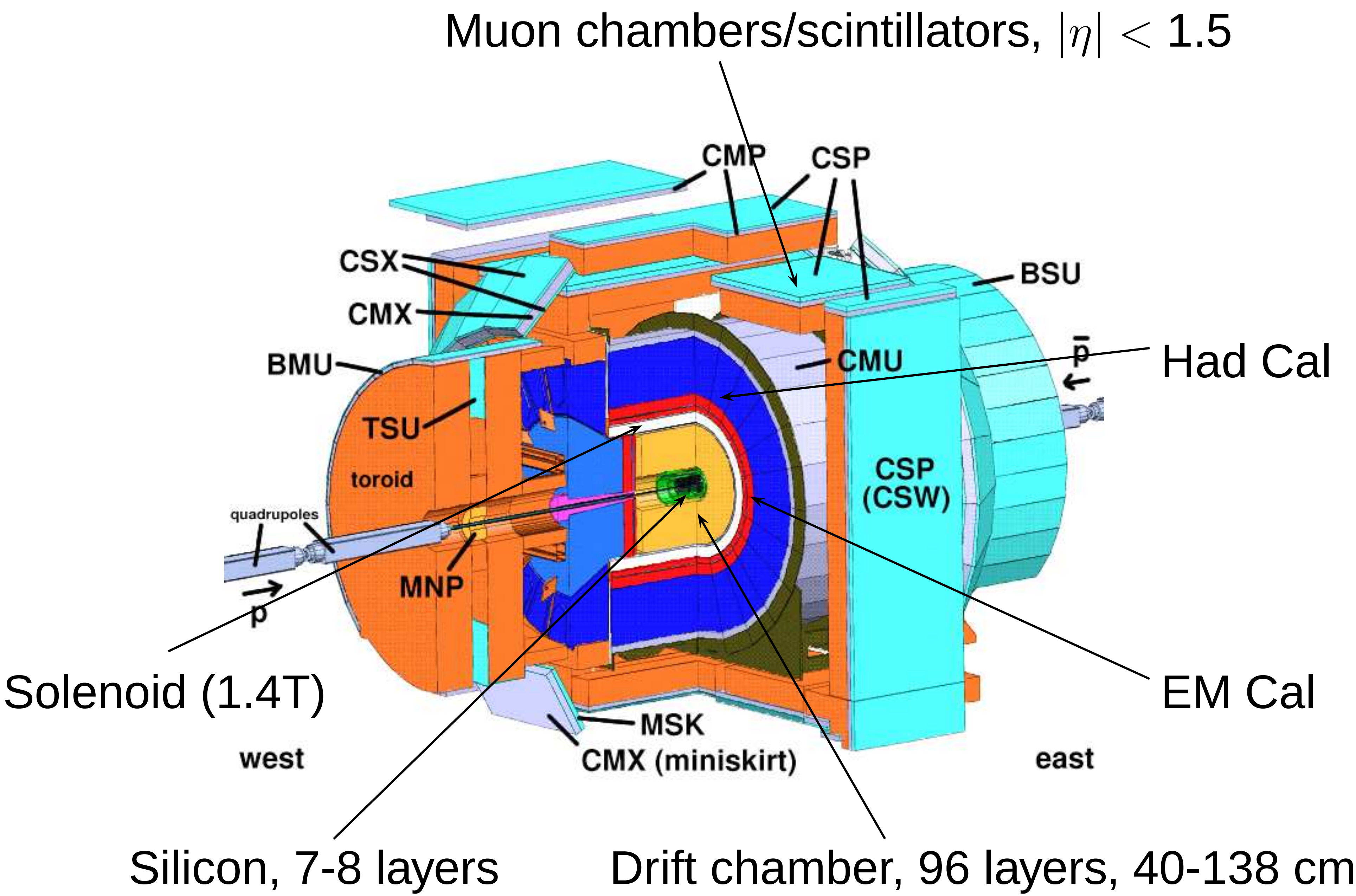
Phys. Rev. D79, 092003



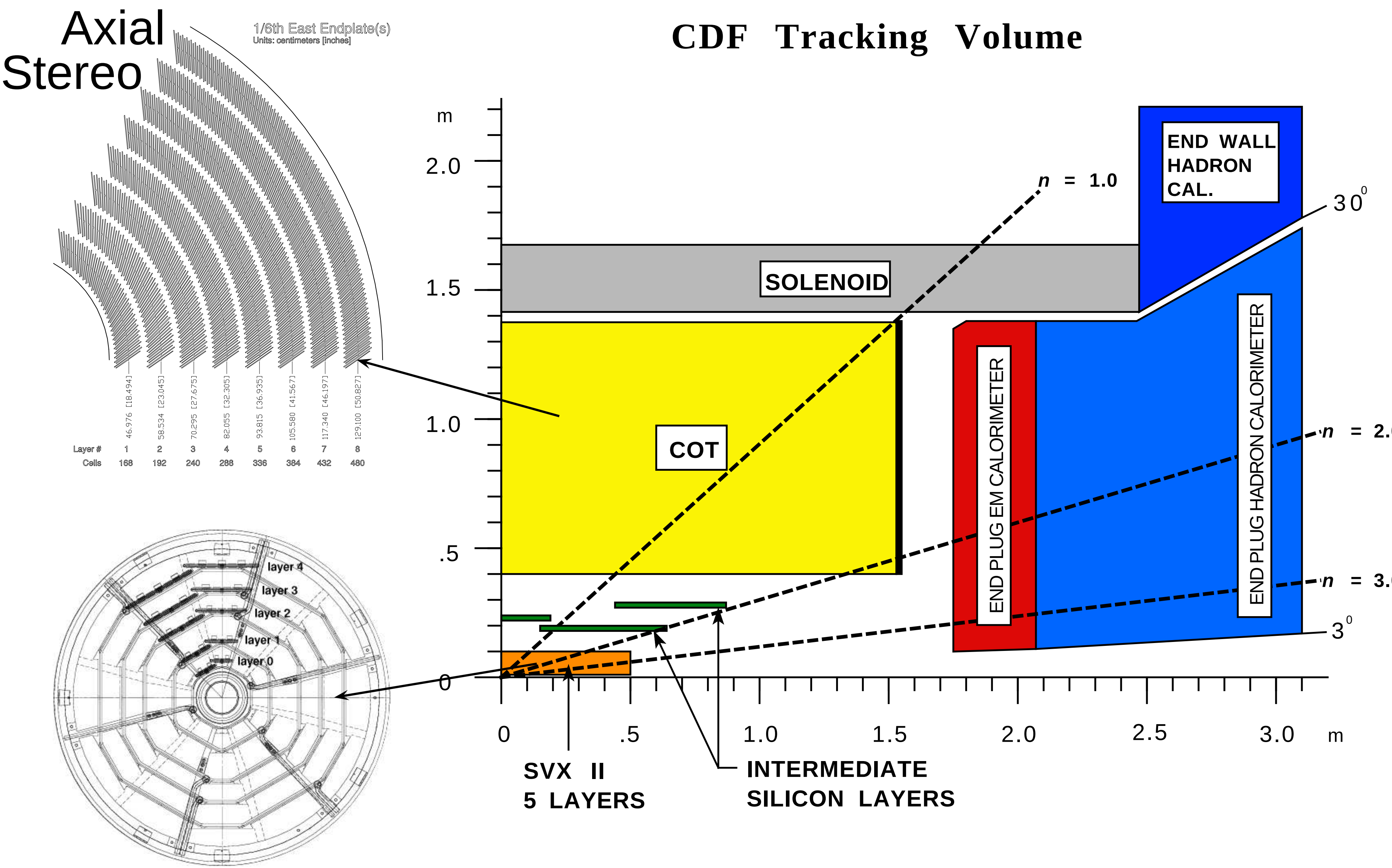


- At Tevatron, *b* production cross section much higher than at B-factories
- Energy much higher then *b*-hadron masses ⇒ All sorts of *b*-hadrons accessible
- Total inelastic cross section ≈ 1000 times larger than *b* cross section ⇒ need to work lot at trigger level

The CDF detector

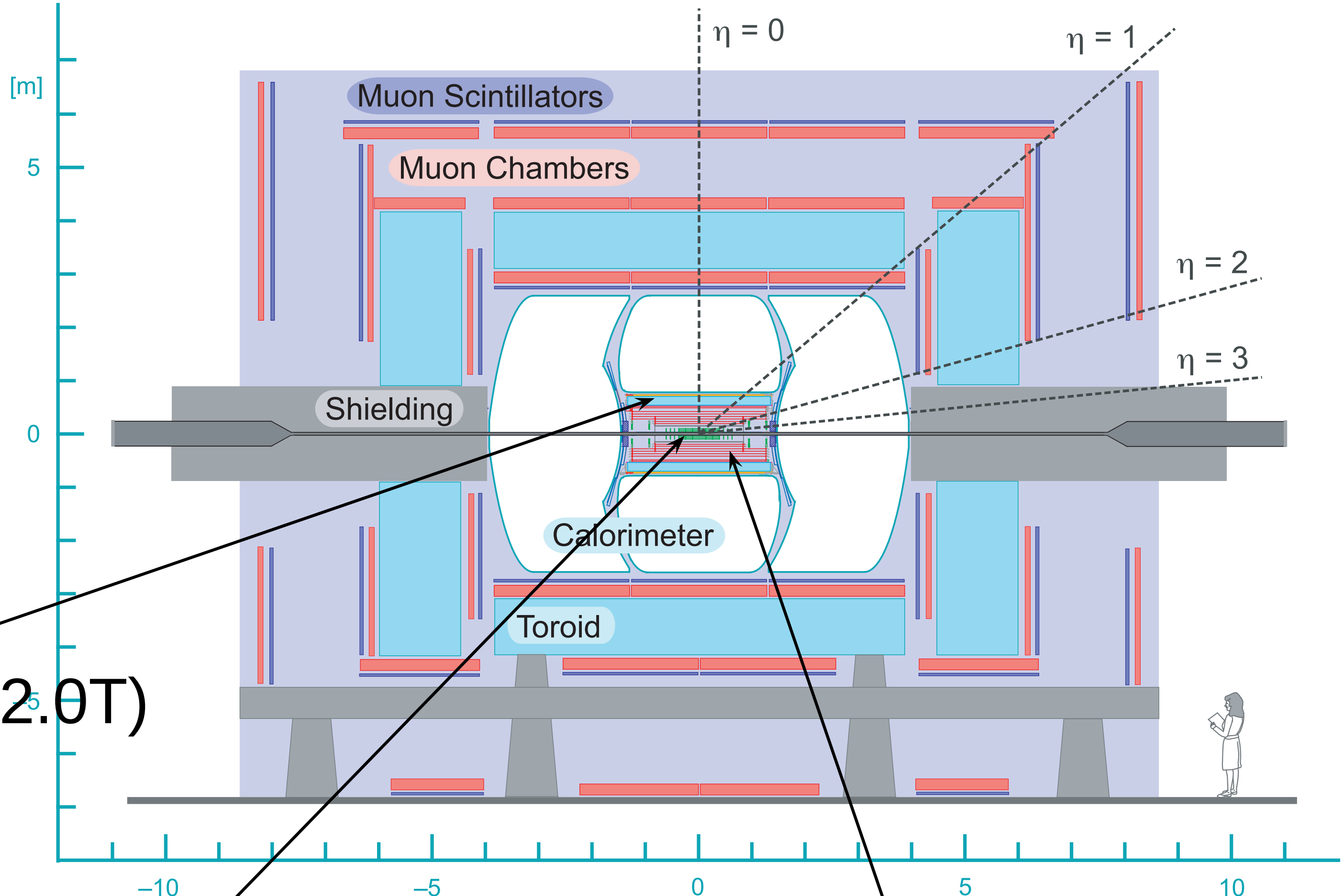


The CDF detector



The DØ detector

Muon system, $|\eta| < 2.0$

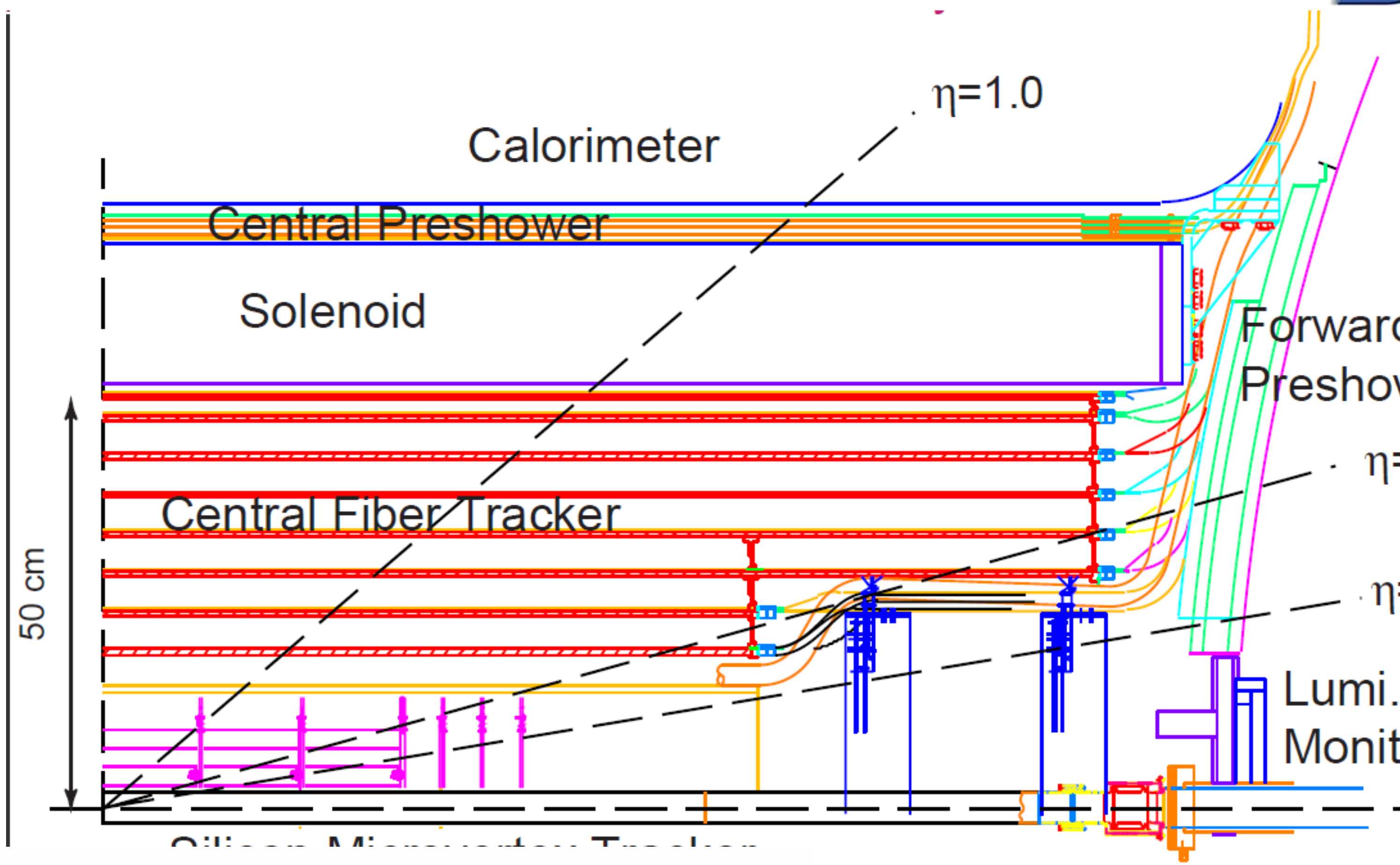


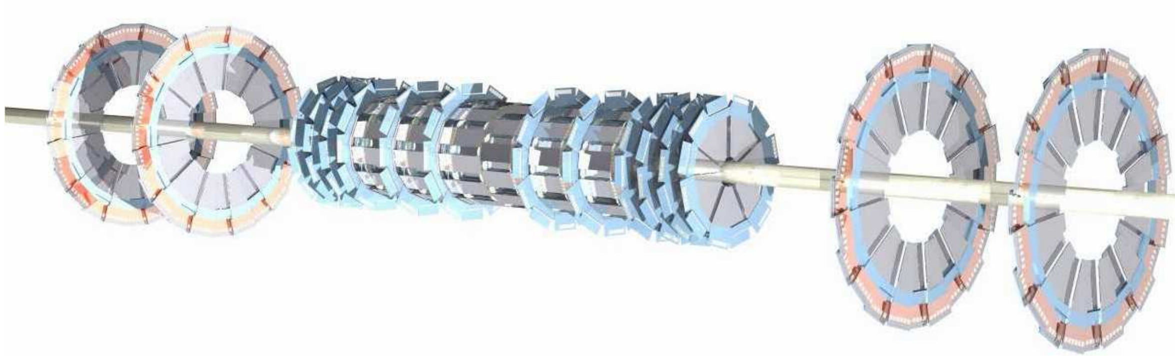
Solenoid (2.0T)

Silicon, 5 layers

Fiber tracker, 16 layers, $\approx$ 50 cm

The DØ detector



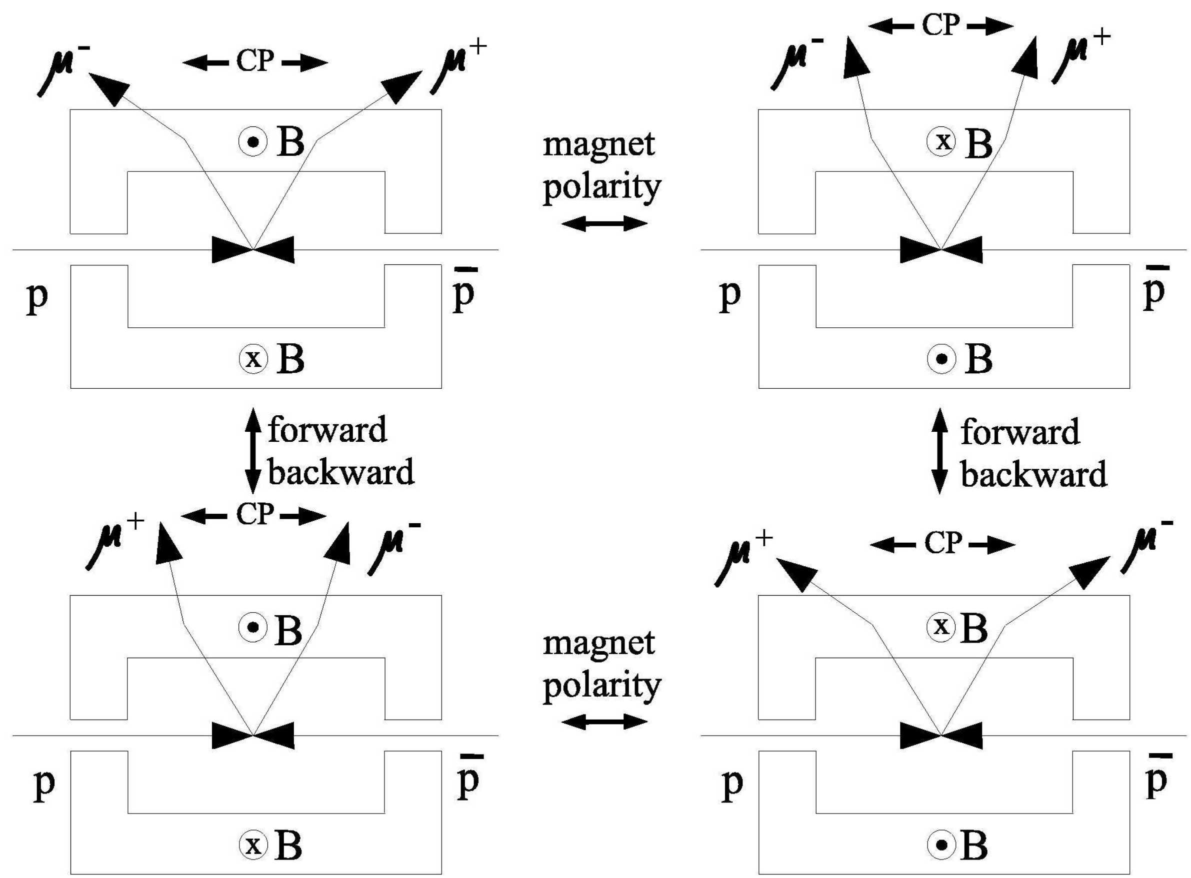


DØ Magnet polarity

Regularly flip magnet polarity

Positive and negative tracks have exactly same acceptance

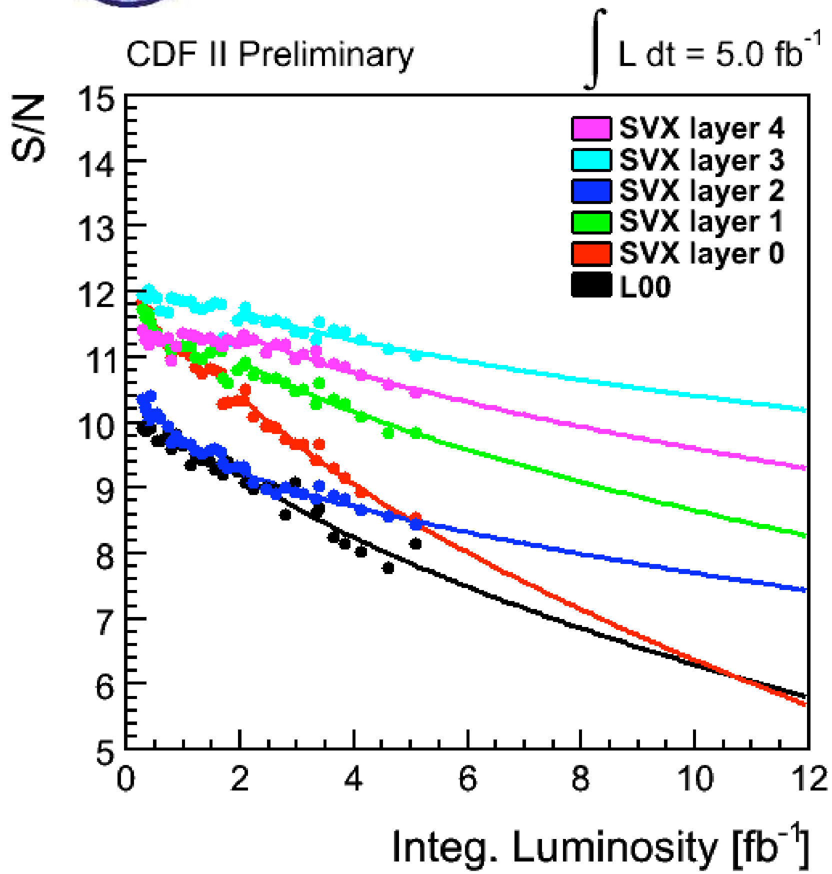
Helps to reduce detector asymmetries

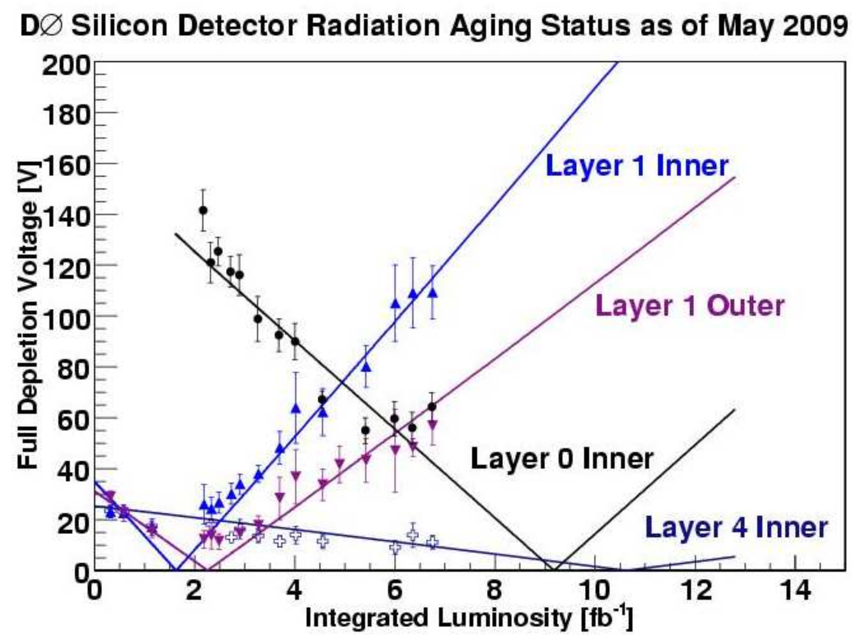


Detectors comparison

	CDF	DØ
Tracking Mom. resolution	$\lvert\eta\rvert < 1$ excellent	$\lvert\eta\rvert < 2$ reasonable
Muons	$\lvert\eta\rvert < 1.5$	$\lvert\eta\rvert < 2.0$ Better purity
Electrons	good	good
K, π PID	TOF, dE/dx	none
Neutrals	Can do something	Probably similar to CDF
B polarity	fixed	regular swap

Silicon detectors status

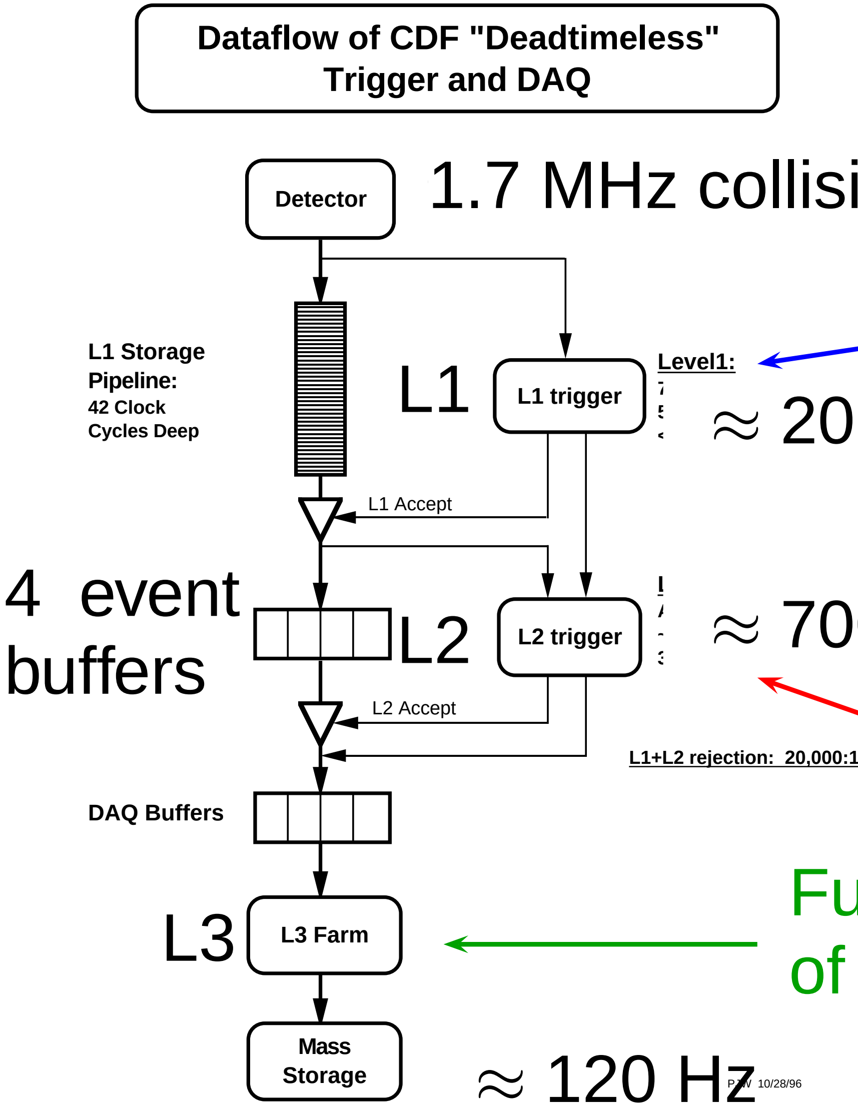




No significant degradation of offline(trigger) tracking for $S/N > 3(6)$ expected

→ Ready for another couple of years data taking

CDF Trigger Architecture



1.7 MHz collision rate

Tracking in drift chamber
Lepton ID

$\approx$ 20 – 30 kHz accept rate

$\approx$ 700 Hz accept rate

Tracking in silicon
Secondary vertex selection

Full reconstruction with offline type of code

$\approx$ 120 Hz

CDF B Triggers

Di-muon

$p_T(\mu) > 1.5$ GeV
$|\eta| < 1$
Υ, J/ψ down to low p_T

Displaced track + lepton

$IP(trk) > 120\ \mu$m
$p_T(l) > 4$ GeV
$|\eta| < 1$
semileptonic B decays

2 displaced tracks

$p_T(trk) > 2$ GeV
$IP(trk) > 100\ \mu$m
$|\eta| < 1$
Fully hadronic decays

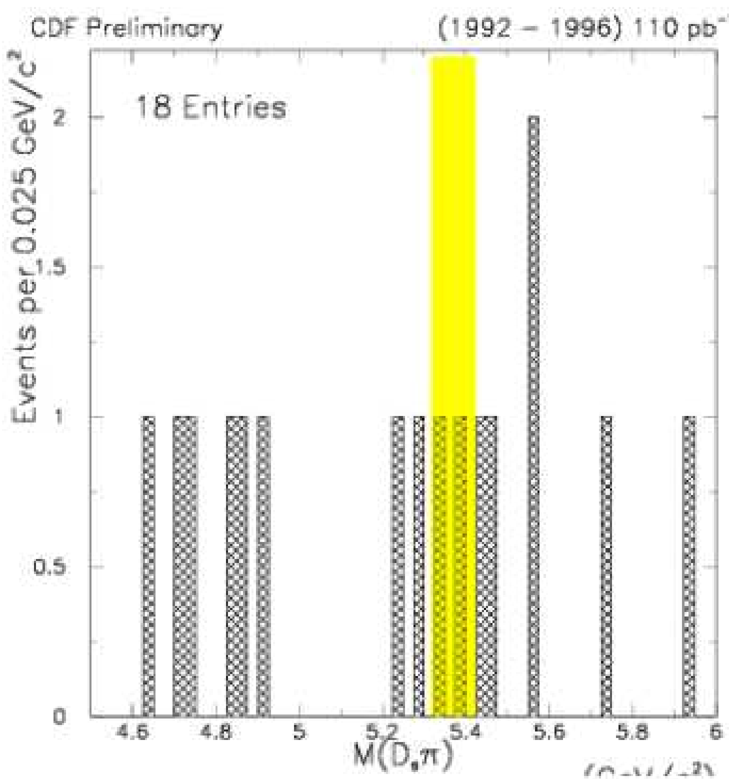
$X(3872) \rightarrow J/\psi\pi\pi$
β_s in $B_s \rightarrow J/\psi\phi$
Ξ_b, Ω_b properties
Lifetimes
$B_{s,d} \rightarrow \mu\mu$
B_c mass, lifetime

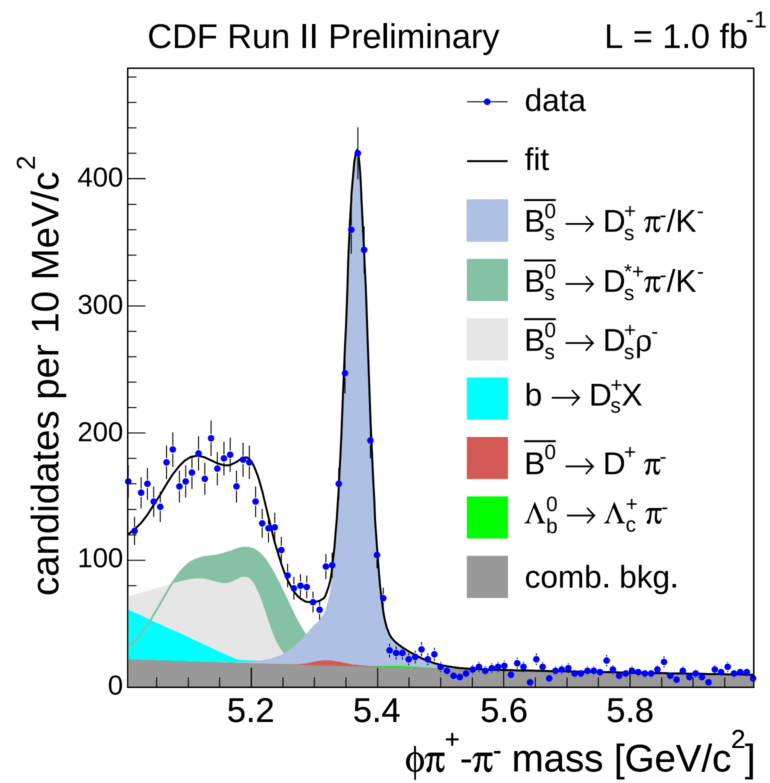
High statistics lifetimes
B mixing
b-hadron production

B_s mixing
D^0 mixing
$B \rightarrow hh$
Σ_b observation
Λ_b studies
$D^0 \rightarrow \mu\mu$
$B_s \rightarrow e^+e^-$

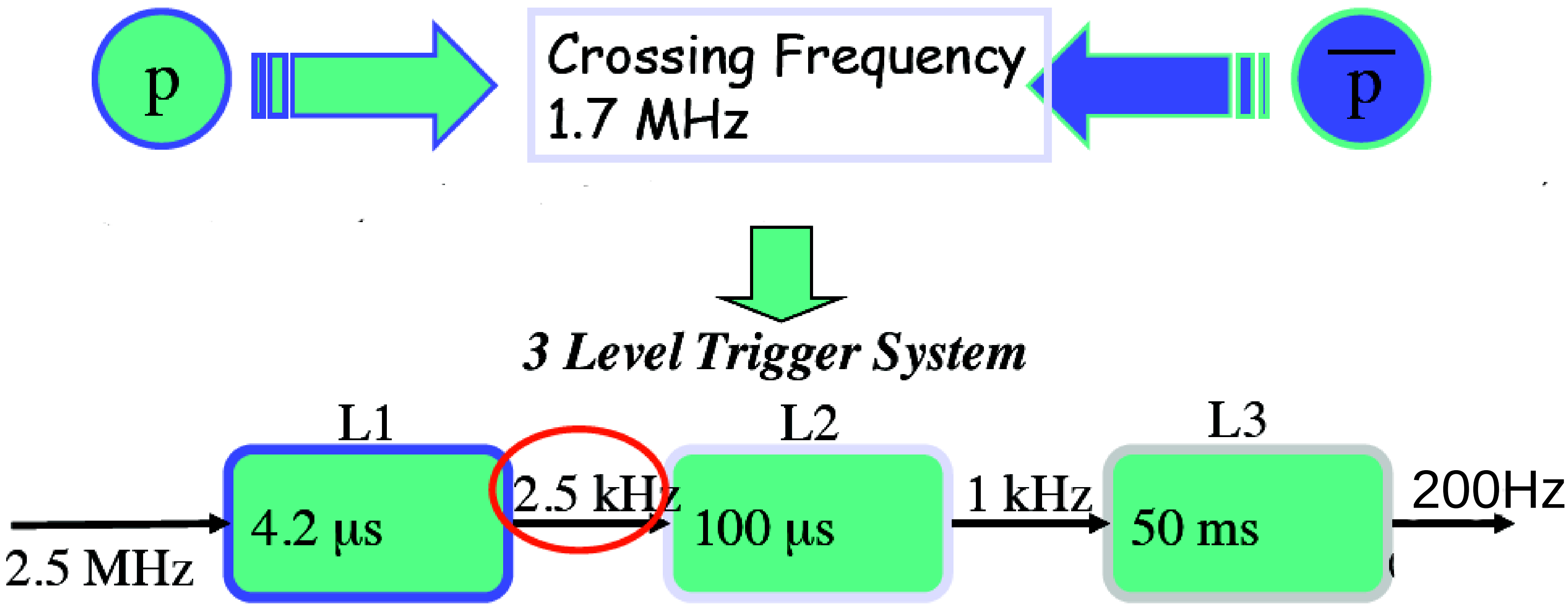
Silicon @ trigger

- Run 1 collected $\mathcal{O}(1)$ of $B_s \rightarrow D_s\pi$ events in 100 pb^{-1}
- Run 2 has about 200 events per same luminosity in single D_s decay
- Using silicon in triggering made huge difference $\Rightarrow$ B_s mixing possible





DØ Trigger



B Triggers

Di-muons:

$p_T(\mu_1) > 3.0$ GeV

$p_T(\mu_2) > 1.5(3.0)$ GeV

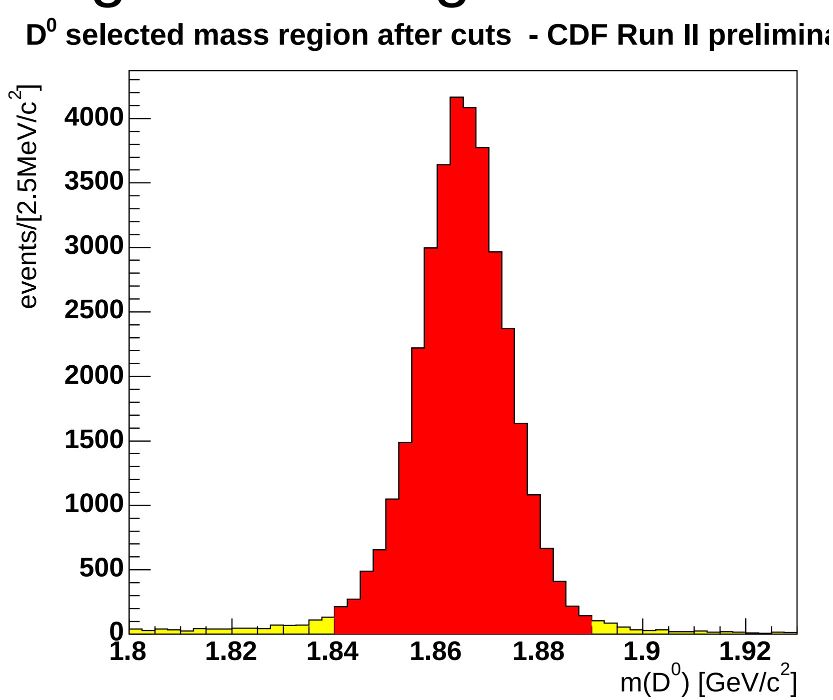
$|\eta| < 2$

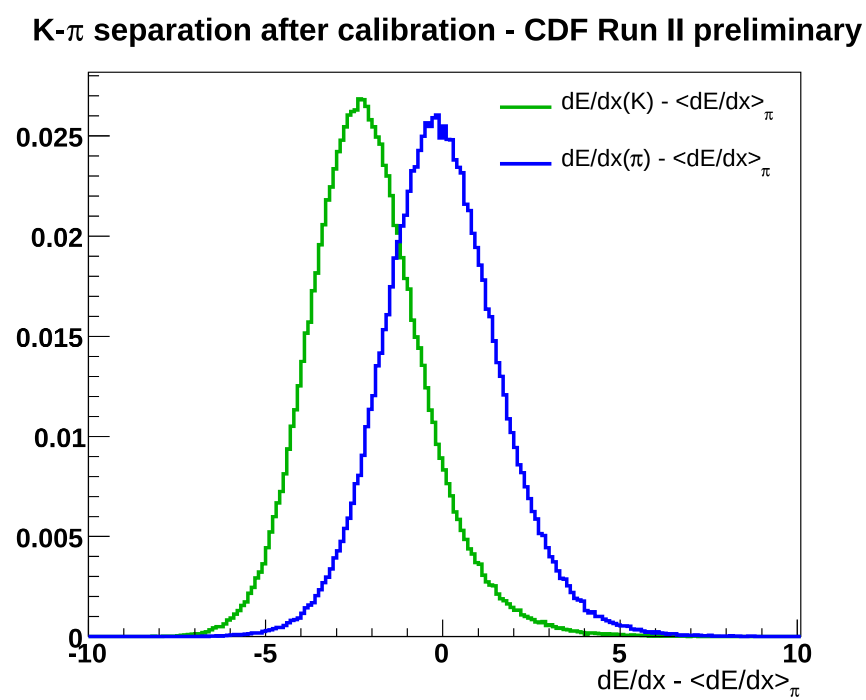
Single muon:

$p_T(\mu) > 3.0$ GeV, $|\eta| < 2$

K, π particle ID

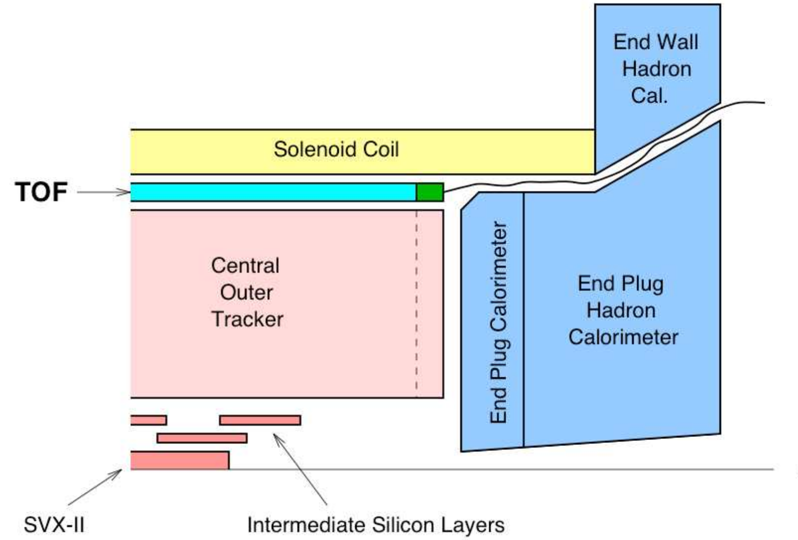
- Use them for d$E/$dx
- Calibrated on large sample of $D^{*+} \to D^0\pi^+ \to [K\pi]\pi^+$
- $\approx 1.4\sigma$ K, π separation
- Since late 2006 as luminosity got higher we don't use 2 innermost superlayers for d$E/$dx
- No significant degradation seen

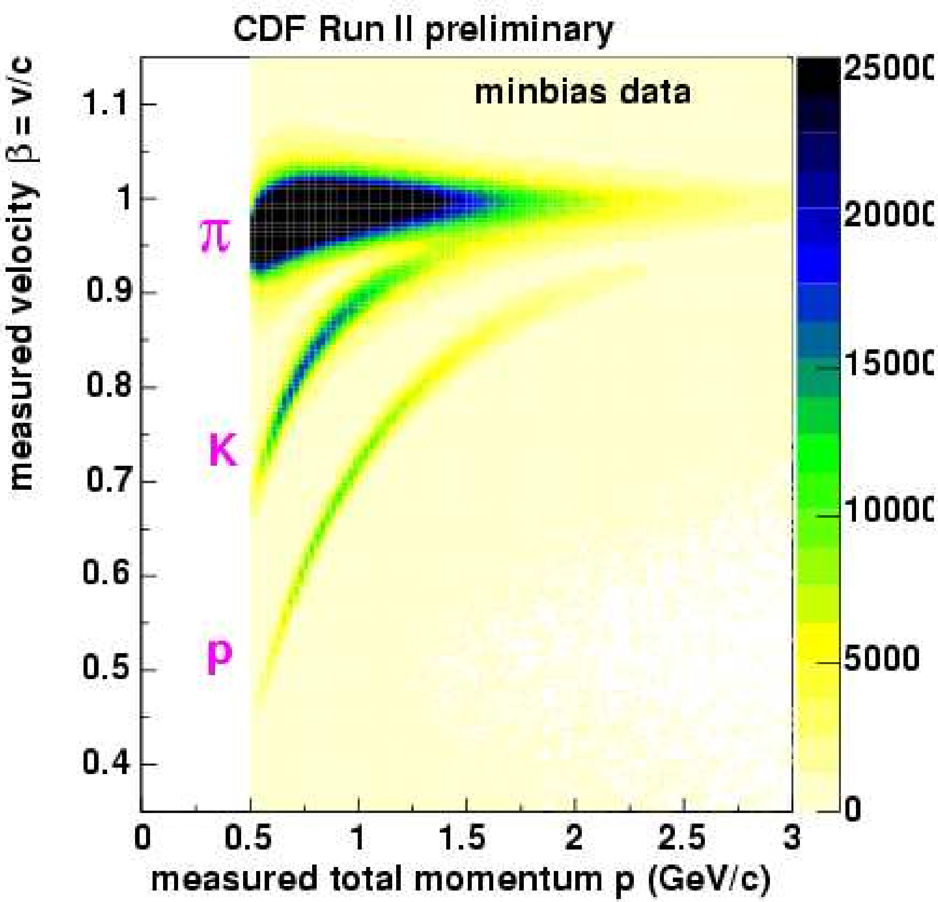


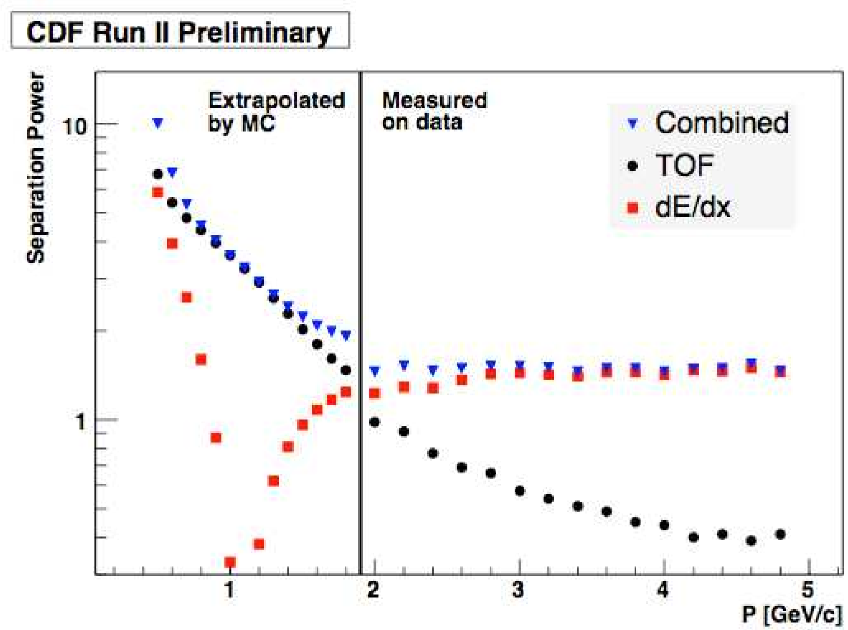


K, π particle ID

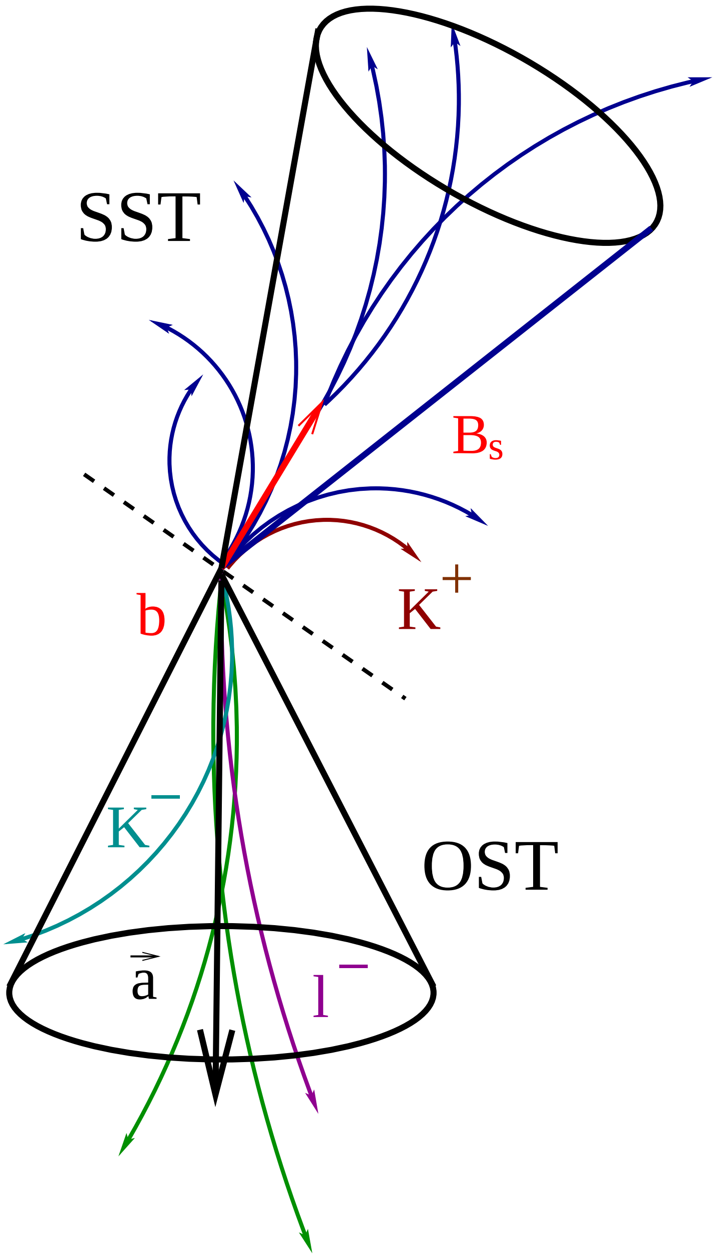
- Time resolution $\approx$ 110 ps
- TOF and dE/dx complementary

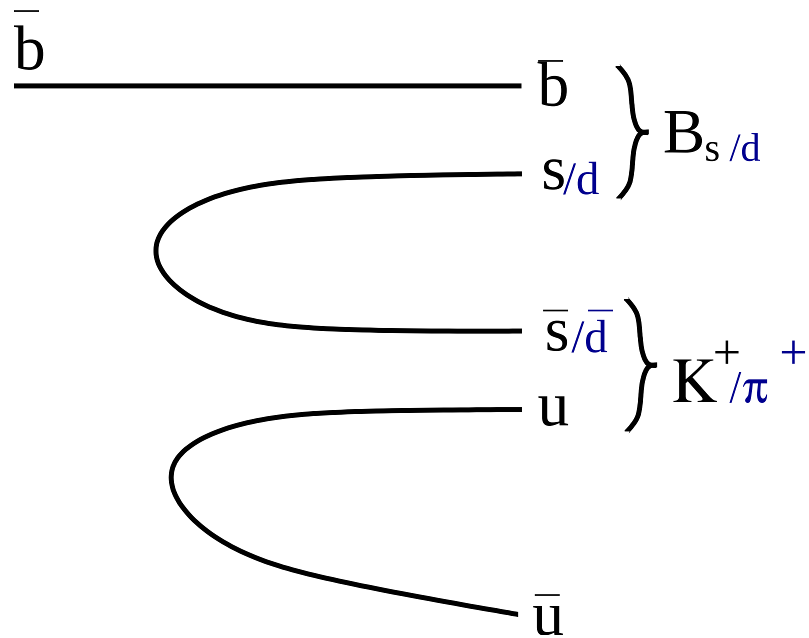






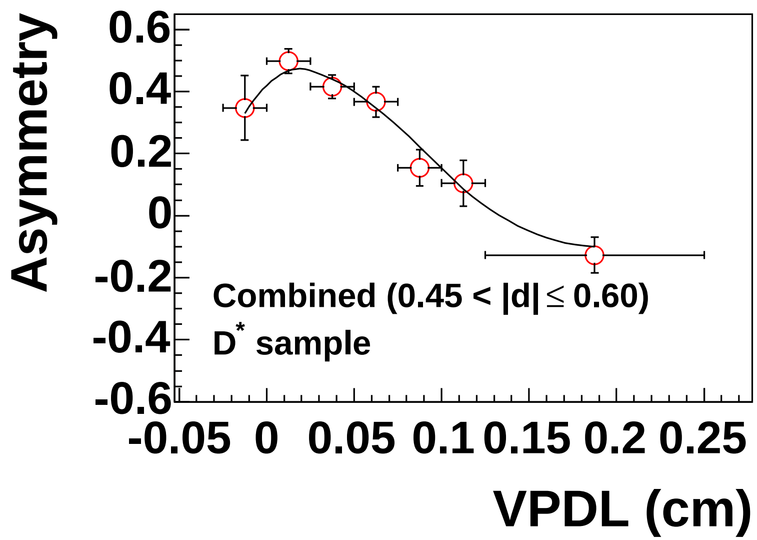
Flavor tagging

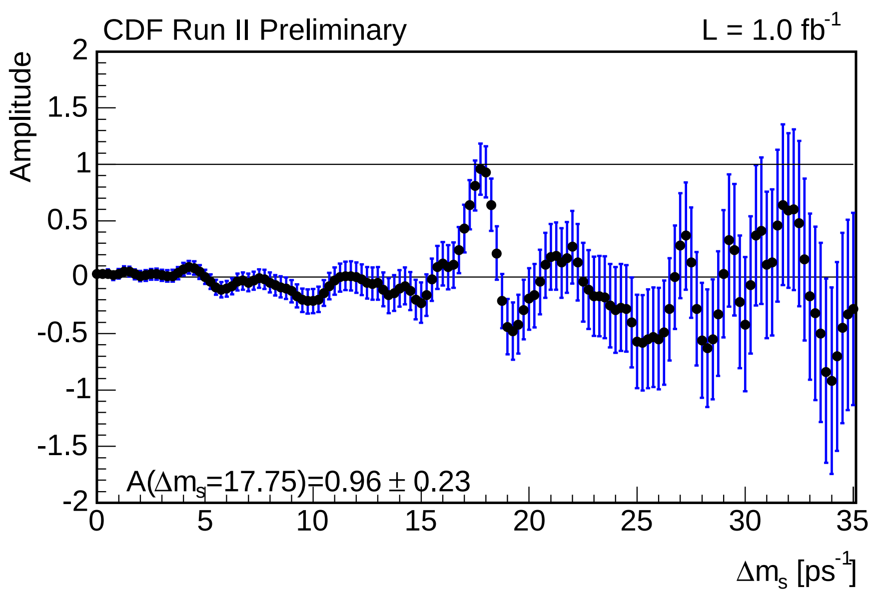




- Both experiments use both same and opposite side tagging
- CDF benefits from PID in same side tagging for B_s
- DØ gains in larger muon acceptance and trigger strategy

Flavor tagging





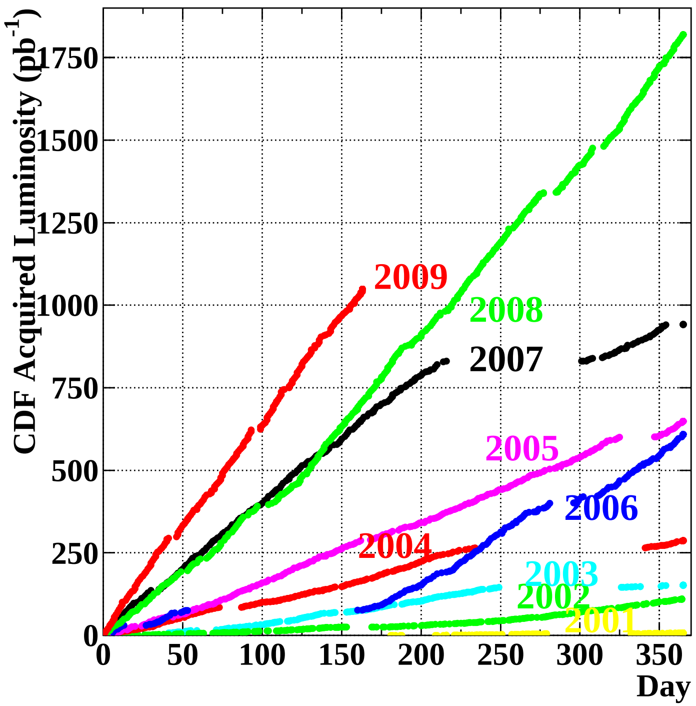
DØ performance:

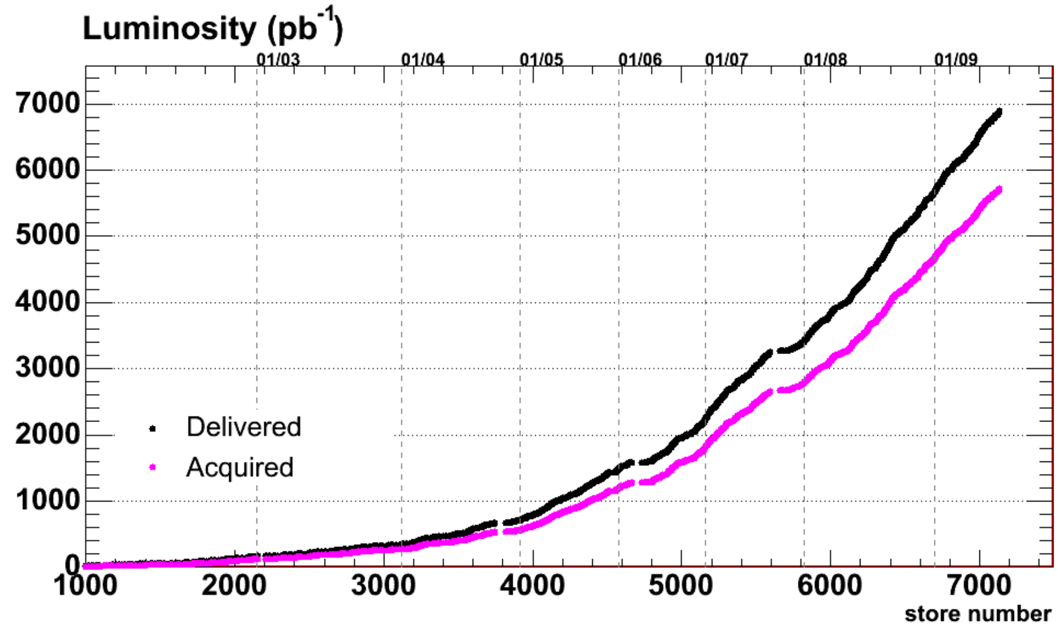
- OST: ϵD^2 = 2.5%
  efficiency=99.7%
  dilution=15.8%
- full: ϵD^2 = 4.7%
  efficiency=100%
  dilution=22%

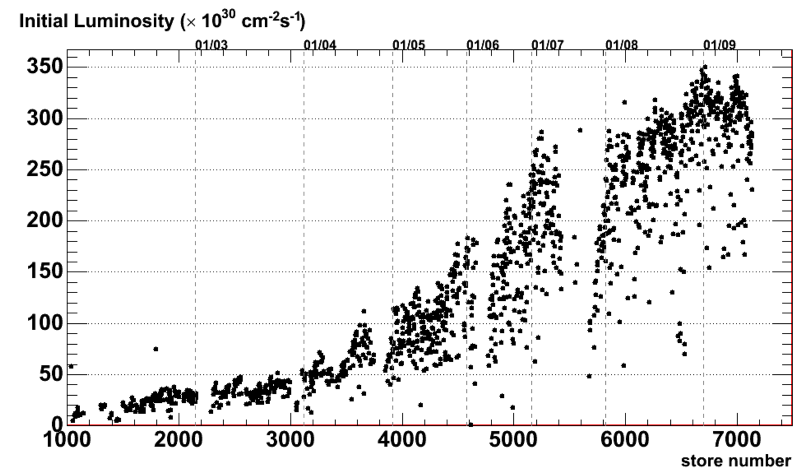
CDF performance:

- OST: ϵD^2 = 1.2%
  efficiency=96%
  dilution=11%
- SST: ϵD^2 = 3.6%
  efficiency=50%
  dilution=27%

Luminosity evolution







- Plots show collected at CDF
- DØ plots look similar
- Get about 1.5-2 fb^{-1} per year
- Projections:
  FY 2010: $\approx$ 9 fb^{-1}
  FY 2011: $\approx$ 12 fb^{-1}

Running at high luminosity

- Generally no large issues with higher luminosities
- We get several additional interactions per bunch crossing
  - No large issue offline, tracking is robust and precise enough
  - Main work to keep triggers alive

$\longrightarrow$ Continuous effort to improve

- Sometimes difficult task at multipurpose detector

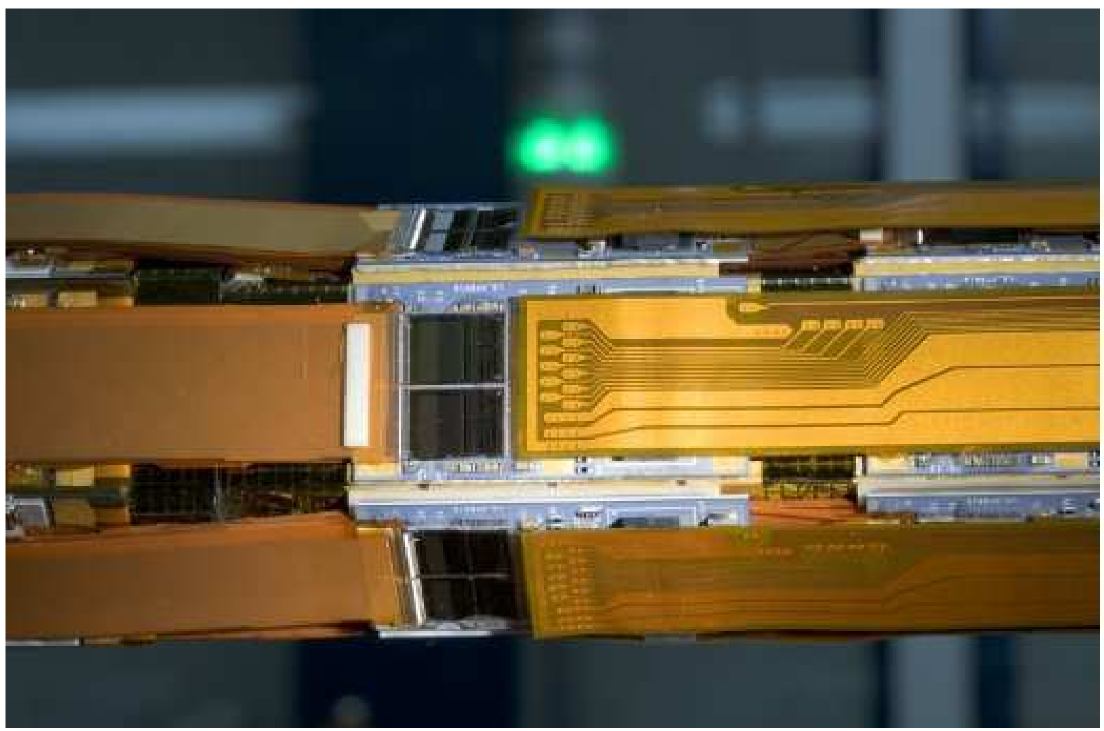
$\longrightarrow$ Have to deal not only with *b*-physics triggers, but also with Higgs triggers

- As luminosity is rising, we are upgrading our trigger system to cope with it

$\longrightarrow$ Will try to convince you that we are going well

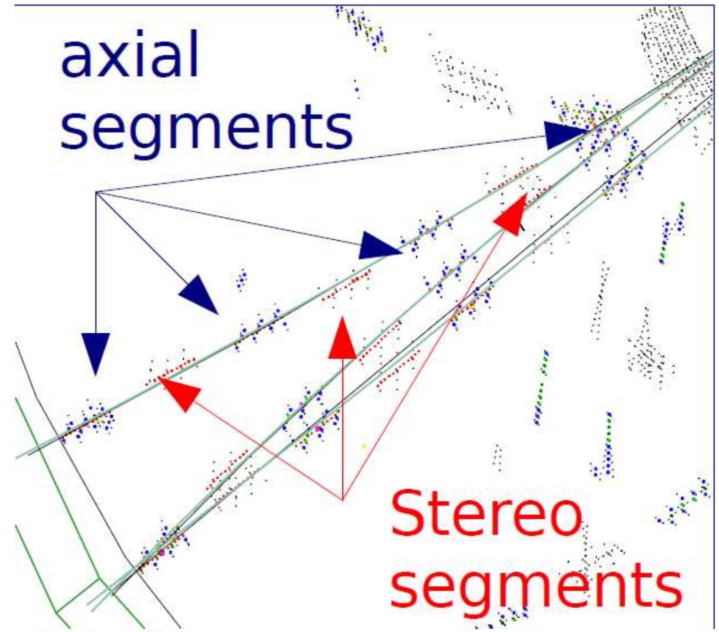
DØ Layer 0

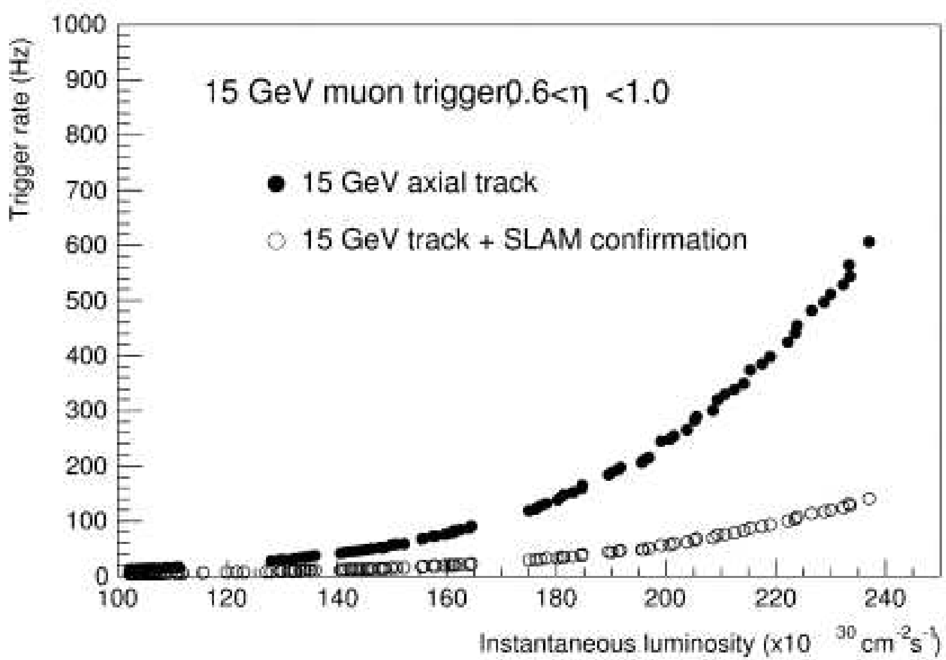
- Install another layer of silicon detector (Layer 0) in 2006
- Mitigate tracking losses due to radiation damage of Layer 1
- Improve impact parameter resolution

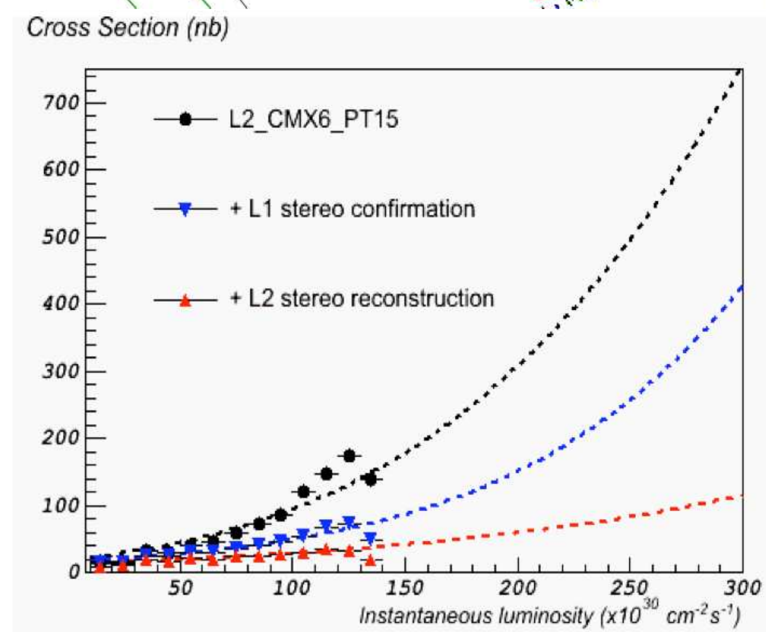


XFT upgrade

- XFT performs tracking in drift chamber at L1
- Original design used only axial layers = half of the chamber
- In 2007 upgrade to include also 3 stereo layers

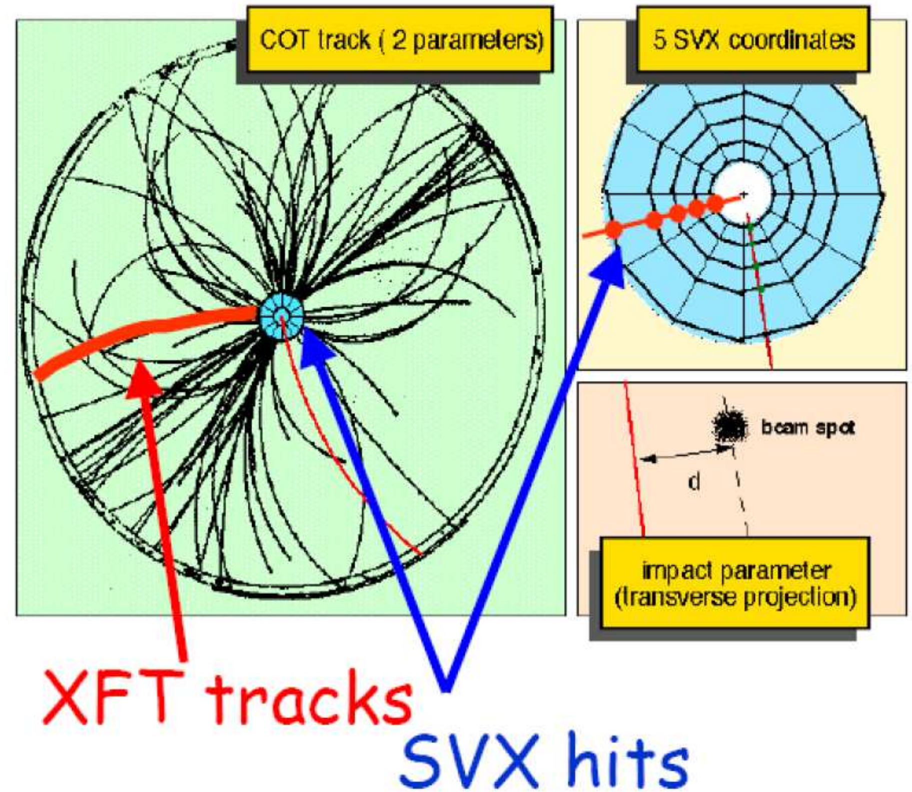






SVT upgrade

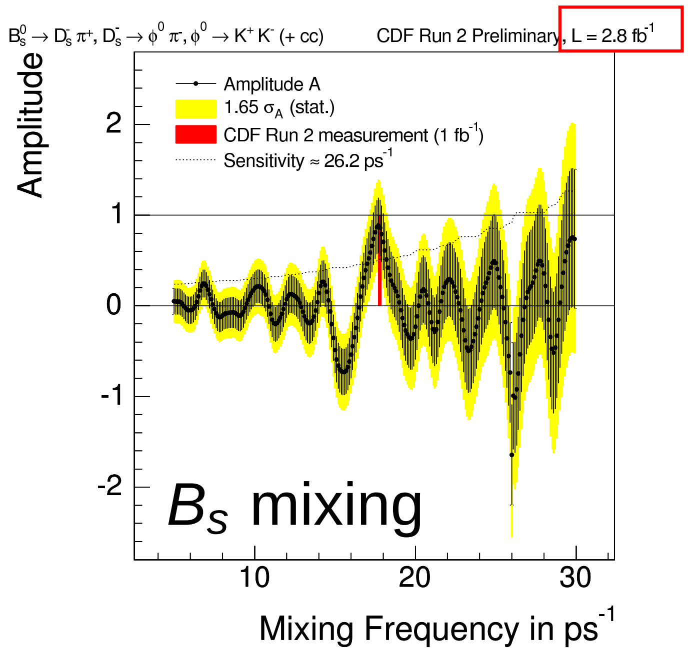
- Take XFT tracks and find corresponding hits in silicon detector
- After track fit obtain precise track parameters, including impact factor
- Allows to select long lived *b*- and *c*-hadrons
- Two steps
  - Compare actual hits to predefined patterns stored in AM
  - Fit tracks found in previous step

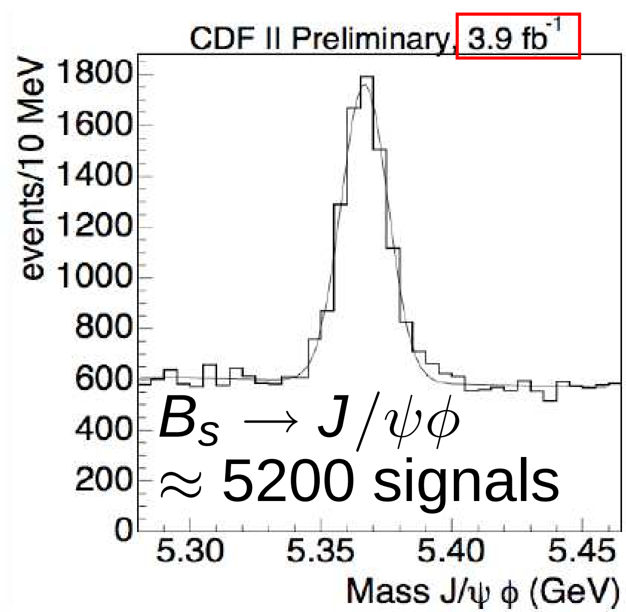


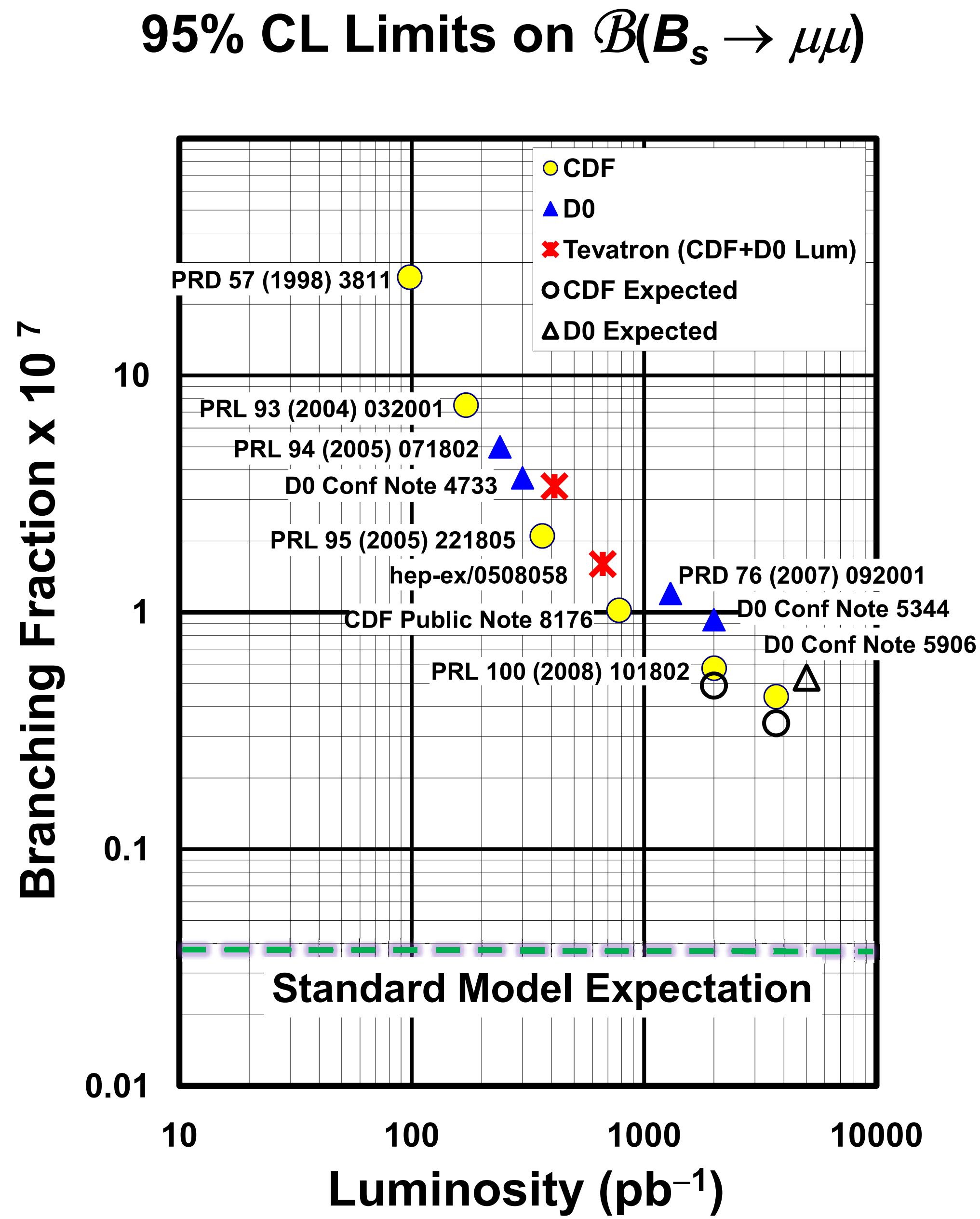
$\rightarrow$ In 2006, install new AMs with more patterns

$\rightarrow$ Currently installing GigaFitter (new generation online track fitting)

How we are doing







Conclusions

- Tevatron running better than ever before and delivering large amount of data
- Both detectors perform very well
- Experiments still active with new ideas to keep up with high luminosity
- Currently coming out of the shutdown
- Expect to start data taking at the end of next week

→ We have well understood detectors taking lot of data

⇒ Expect lot of new results from Tevatron